

Title: Autonomous Multi-Layer Exergy Generator **Inventor:** Ronald Yarborough III **Date:** September 9, 2025 **License:** Creative Commons Attribution-NonCommercial-ShareAlike (CC BY-NC-SA)

□ **Abstract**

A self-powered, multi-layer energy harvesting system designed for remote sensor nodes and modular deployment. The device integrates triboelectric, hygroelectric, piezoelectric, magnetostrictive, thermoelectric, radiative cooling, photovoltaic, and ambient light photovoltaic modules in a stacked configuration. It features AI-driven microcontrollers that dynamically prioritize high-exergy sources using real-time environmental feedback. The system includes modular expansion ports, adaptive layer reconfiguration, and a hybrid energy storage system composed of supercapacitors and solid-state batteries. This architecture enables fully autonomous operation in off-grid environments with scalable power output and long-term energy storage.

□ **Schematic Description**

Layered Architecture

Layer	Function	Synergy
Top Surface	Triboelectric + Hygroelectric	Captures motion and moisture
Middle Layer	Piezoelectric + Magnetostrictive	Converts strain and vibration
Core Layer	Thermoelectric + Radiative Cooling	Harvests heat and nighttime cooling
Base Layer	Photovoltaic + Ambient Light PV	Captures daylight and indoor illumination

Enhancements

- Dynamic Layer Reconfiguration: MEMS-based switching allows physical or electrical rerouting of energy flow
- Environmental Sensing Feedback: Embedded sensors monitor humidity, vibration, light, and temperature
- Modular Expansion Ports: Magnetic or snap-fit connectors allow chaining multiple units
- Thermal Management: Phase-change materials and heat spreaders optimize TEG performance

⚙ **Energy Routing & Storage Optimization**

- AI Microcontroller: Real-time exergy mapping and adaptive prioritization
- DC-DC Converters: Voltage regulation across heterogeneous inputs
- Supercapacitors: Fast cycling for tribo/piezo surges
- Solid-State Batteries: Long-duration storage for PV and TEG layers

□ Exergy Cascade Logic

- Domino Effect Activation: Environmental triggers sequentially activate layers
- Self-Tuning Feedback: AI controller adapts harvesting strategy based on sensor input

□ Use Cases

Application	Description
Remote Sensor Nodes	Environmental monitoring, industrial diagnostics, off-grid communications
Wearables	Body-powered health trackers using motion, sweat, and ambient light
Marine Platforms	Buoys and underwater sensors using salinity, motion, and solar
Smart Agriculture	Soil sensors powered by moisture, light, and vibration
Industrial Machinery	Waste heat and vibration recovery for predictive maintenance

Claims

1. A multi-layered energy harvesting device comprising triboelectric, hygroelectric, piezoelectric, magnetostrictive, thermoelectric, radiative cooling, photovoltaic, and ambient light photovoltaic modules arranged to trigger sequential energy conversion.
2. The system of claim 1, wherein an AI microcontroller dynamically prioritizes energy sources based on environmental exergy mapping.
3. The system of claim 1, further comprising a hybrid energy storage system including supercapacitors and solid-state batteries.
4. A method for autonomous operation of a remote sensor node using the system of claim 1, wherein energy is harvested, routed, and stored without external power input.
5. The system of claim 1, wherein the layered configuration enables a domino-effect activation of energy harvesting modules based on environmental feedback.
6. The system of claim 1, further comprising dynamic layer reconfiguration based on environmental conditions.

7. The system of claim 1, further comprising modular expansion ports for scalable deployment.
8. A method for adaptive energy harvesting using embedded environmental sensors to inform routing logic.

□ **Statement of Intent**

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□ **Attribution**

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